

Original citation:

Yeung, Joyce, Kovic, Ivor, Vidacic, Marija, Skilton, Emma, Higgins, Dan, Melody, Teresa and Lockey, Andrew. (2017) The school Lifesavers study - a randomised controlled trial comparing the impact of Lifesaver only, face-to-face training only, and Lifesaver with face-to-face training on CPR knowledge, skills and attitudes in UK school children. *Resuscitation*, 120 . pp. 138-145.

Permanent WRAP URL:

<http://wrap.warwick.ac.uk/93282>

Copyright and reuse:

The Warwick Research Archive Portal (WRAP) makes this work by researchers of the University of Warwick available open access under the following conditions. Copyright © and all moral rights to the version of the paper presented here belong to the individual author(s) and/or other copyright owners. To the extent reasonable and practicable the material made available in WRAP has been checked for eligibility before being made available.

Copies of full items can be used for personal research or study, educational, or not-for-profit purposes without prior permission or charge. Provided that the authors, title and full bibliographic details are credited, a hyperlink and/or URL is given for the original metadata page and the content is not changed in any way.

Publisher's statement:

© 2017, Elsevier. Licensed under the Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International <http://creativecommons.org/licenses/by-nc-nd/4.0/>

A note on versions:

The version presented here may differ from the published version or, version of record, if you wish to cite this item you are advised to consult the publisher's version. Please see the 'permanent WRAP url' above for details on accessing the published version and note that access may require a subscription.

For more information, please contact the WRAP Team at: wrap@warwick.ac.uk

Title:

The School Lifesavers Study – A Randomised Controlled Trial comparing the impact of Lifesaver only, face-to-face training only, and Lifesaver with face-to-face training on CPR knowledge, skills and attitudes in UK school children

Joyce Yeung^a, Ivor Kovic^b, Marija Vidacic^b, Emma Skilton^c, Dan Higgins^d, Teresa Melody^e, Andrew Lockey^{f*}

a) Associate Clinical Professor, University of Warwick, UK

b) Specialty Doctor, Calderdale & Huddersfield NHS Trust, UK

c) Clinical Trial Coordinator, University of Warwick, UK

d) Advanced Clinical Practitioner, Heart of England NHS Trust, UK

e) Critical Care Research Department Manager, Heart of England NHS Trust, UK

f) Consultant in Emergency Medicine, Calderdale & Huddersfield NHS Trust, UK

Corresponding author: Dr Andrew Lockey (Andrew.lockey@cht.nhs.uk)

Word Count: 2999 words

Abstract

Background

Lifesaver (www.life-saver.org.uk) is an immersive, interactive game that can be used for basic life support training. Users 'resuscitate' a victim of cardiac arrest in a filmed scenario and move their device up and down to simulate cardiac compressions.

Methods

Randomised controlled trial of 3 UK schools (81 students) comparing Lifesaver, face-to-face (F2F) training, and a combination of both. Primary outcomes: mean chest compression rate and depth. Secondary outcomes: flow fraction, CPR performance assessment, and attitude survey. Outcomes measured immediately, 3 and 6 months.

Results

Primary outcomes: Mean chest compression depth was suboptimal in all groups due to body size. F2F performed better than Lifesaver initially (-11.676; 95% CI -18.34 to -5.01; $p=0.0001$) but no difference at 3 months ($p=0.493$) and 6 months ($p=0.809$). No difference in mean compression rates for Lifesaver vs F2F (-11.89; 95% CI -30.39 to -6.61; $p=0.280$) and combined vs Lifesaver (0.25; 95% CI -17.4 to -17.9; $p=0.999$). Secondary outcomes: all groups had flow fraction >60% after training. Combined group performed better for skills assessment than Lifesaver (4.02; 95% CI 2.81 to 5.22; $p=0.001$) and F2F (1.76; 95% CI 0.51 to 3; $p=0.003$); and the same at 6 months (1.92; 95% CI 0.19 to 3.64; $p=0.026$ and 1.96; 95% CI 0.17 to 3.75; $p=0.029$).

Conclusions

Use of Lifesaver by school children, compared to F2F training alone, can lead to comparable learning outcomes for several key elements of successful CPR. Its use can be considered where resources or time do not permit formal F2F training sessions. The true benefits of Lifesaver can be realised if paired with F2F training.

Introduction

The United Kingdom has one of the highest rates of cardiovascular disease in the world and approximately 60,000 out-of-hospital cardiac arrests (OHCA) occur every year, half of which are attended to by the emergency services [1,2,3]. Basic Life Support (BLS) can improve outcomes if it is swiftly performed at the scene of the cardiac arrest.

One of the main elements of BLS is cardiopulmonary resuscitation (CPR). Bystander CPR is important because it slows down the rapid decline in a patient's chances of survival while waiting for professional help. Currently the average bystander CPR rates in the UK range between 39 and 57% with survival to hospital discharge rates of 7.9% [3].

CPR training in school children

While educating the lay public in BLS is key to increasing survival from cardiac arrests, it is difficult to reach the entire population. One potential strategy is to educate school children as young as 12 years old. The American Heart Association advocated compulsory resuscitation training in American schools in 2011 [4]. Countries in which resuscitation has been integrated into school educational programs report significantly higher resuscitation rates [5-7]. Successful training of school children in Denmark has led to double the rate of bystander CPR after five years, and a threefold improvement in survival following OHCA over ten years [5,7].

In March 2013, the Department of Health in England published a Cardiovascular Disease Outcomes Strategy [8]. The Community Resuscitation Group was convened to develop a national approach to achieve the objectives of the strategy [9], leading to the publication in 2017 of the 'Resuscitation to Recovery' framework [10]. It recommended "greater awareness amongst the general public, including young people of school age, on how to recognise and manage cardiac arrest through the use of CPR and defibrillators".

In their systematic review, Plant and Taylor found that training school children in CPR from the age of 10 years old is effective [11-13]. It has been shown that early training helps reduce anxieties about making mistakes in an emergency and markedly increases participants' willingness to help [2,13,14].

Lifesaver

Lifesaver (www.life-saver.org.uk) is an innovative, immersive, and interactive game that can be played for free on smartphones, tablets or online. The novel 'game-in-film' format provides an engaging learning experience with real life scenarios. Users become actively involved with the resuscitation of a victim of cardiac arrest and move their device up and down to simulate cardiac compressions. If a wrong decision is made, the user sees the impact but is then able to rewind and make the correct decision. It was produced by Resuscitation Council (UK) using charitable funds and generates no financial income.

Study Aims

To compare the effect of Lifesaver training only, face-to-face (F2F) training only, and a combination of Lifesaver and F2F training with regard to:

Primary outcomes:

- chest compression depth (mm) and rate (compressions per minute)

Secondary outcomes:

- flow fraction – percentage of time where compressions given (recommended >60% for single-handed CPR to improve patient outcomes) [15]
- CPR score, including whether CPR was successfully achieved – maximum score of 10, using the European Resuscitation Council CPR/AED-P course assessment document (Appendix 1)
- attitudes toward resuscitation

Methods

Trial Design and Setting

The study design was a three-armed randomised controlled trial. The participating schools held Academy status (state-funded schools directly funded by the Department for Education and independent of local authority control thus giving greater flexibility to deliver training during school time). To be included, they also had to commit to three study visits and be willing to provide written informed consent. A convenience sample of one class of school children per school was used for each arm. The primary and secondary outcomes used are detailed above.

All Academy schools within the central Birmingham area were eligible to participate except those who were already participating in an established school CPR training programme (e.g. British Heart Foundation 'Heartstart'). Letters of invitation were posted to eligible schools in the area and the first three schools that responded were selected.

One class of Year 8 students (12-13 years old) from each of the three participating secondary schools was selected by their head teacher based upon timetabling requirements. Each school was randomised to group intervention using electronic random number generation:

School 1: standardised F2F BLS training only;

School 2: Lifesaver training only;

School 3: Lifesaver training in addition to standardised F2F BLS training.

Study information sheets detailing the background, aim and methods were posted to parents and signed consent forms were collected prior to student participation. Parents were asked to discuss participation with their child before giving consent on their behalf. Verbal consent from students was also collected on each occasion before students were assessed. The study was approved by the University of Birmingham Ethics Committee.

Study Interventions

A standardised approach was developed and delivered to all groups by a member of the research team (DH), who is a trained BLS instructor. Each training session commenced with a short introduction about sudden cardiac arrest and the need for timely and good quality bystander CPR.

Group 1 – F2F instructor led training session only

The F2F element was standardised. Each pupil took turns practicing BLS skills on a manikin. The ratio of instructors to pupils was 1:6 to ensure that adequate time and attention was given to each pupil.

Group 2 - Lifesaver only training session

The Lifesaver programme was introduced and pupils were provided with a handheld tablet to complete the programme. No additional F2F instruction or practical hands-on training (other than use of Lifesaver) was provided.

Group 3 - Lifesaver and F2F instructor led training session

The Lifesaver programme was introduced and pupils were provided with a handheld tablet to complete the programme for the same exposure time as Group 2. Pupils were then rotated to an instructor led session with a standardised F2F element which followed the same format and exposure time as Group 1.

Data collection

Baseline knowledge and attitude

Baseline data on knowledge and attitude towards performing bystander CPR was collected for all three groups by questionnaire prior to any educational intervention. The attitudes questionnaire included four statements with five-point Likert type scale answers (Appendix 2). Higher scores

were awarded for positive attitudinal answers. Each group also completed a written knowledge test consisting of eight multiple choice questions, with one correct answer per question, covering the topics represented in both Lifesaver and the face-to-face course (Appendix 3). These questionnaires were developed with input from a lay person who is a schoolteacher and the NIHR Clinical Research Network West Midlands Young Persons' Steering Group to ensure that questions were clear and suitable for Year 8 students.

Immediate post intervention

Students were asked to demonstrate CPR skills on manikins immediately following training and they were assessed by independent BLS trained assessors (medical students from the University of Birmingham). Each student received a scenario in which a person, represented by the manikin, was lying on the floor. They were asked to demonstrate what they would do to help. Whilst the assessors were not truly blind to the intervention, they were independent to the study. The assessors used standardized CPR assessment forms to assess the skills of each student (Appendix 1). All interactions between students and the manikin, including chest compression parameters, were recorded using Resusci Anne SkillReporter™ software (Laerdal Medical, Norway) and collected by remote laptop for analysis. No feedback was given to any student during or after testing.

Skill retention and follow up

CPR skill performance was tested at 3 and 6 months after initial training by identical scenarios and practical demonstration of CPR skills on manikins. Performance was again assessed by independent assessors. During follow up, students were asked if they had an opportunity to use their skills and if so, to describe their experience.

Statistical Analysis

Data were analysed separately by members of the research team blinded to group allocation (IK and JY). Statistical analyses were performed using SPSS version 21.0. Normality of data was checked using the Kolmogorov-Smirnov Z test. Differences between the three groups in chest compression parameters and CPR assessment performance data were analysed using one-way ANOVA and Tukey HSD test.

Results

Eighty-one children from three participating schools were recruited into the study (Figure 1). Twenty-seven had F2F only training, twenty-five students received Lifesaver training only, and twenty-nine had both Lifesaver and F2F training. The participant numbers in each group differed slightly due to the size of class taking part.

None of the students who participated had to perform CPR in real life during the study period.

Participants were aged between 12 and 13 years old. There were 9 boys (33.3%) in the Lifesaver only group, 13 (52%) in the F2F group, and 14 (48.3%) in the combined group. Initial training and assessments took place in April 2016, with 3 and 6-month follow-up in July and October 2016. No further training or feedback on CPR performance was provided after the initial allocated training. Due to some school children being off sick and changing schools during the intervening summer holidays, there was a small loss of follow-up across all three groups. The students who missed the 3 month follow up were excluded from the 6-month assessment.

Baseline knowledge (Table 1)

There was no significant difference in baseline knowledge between the three groups (F2F only mean score 3.13 (SD 0.95), Lifesaver only mean score 3.30 (SD 1.56), Combined mean score 2.55 (SD 1.09), $p=0.067$).

Primary Outcomes - Quality of chest compressions (Table 2)

For the primary outcome of mean chest compression depth, the Lifesaver group performed the worst at initial assessment (-11.676 compared with F2F; $p=0.0001$, -16.13 compared with combined; $p=0.0001$). Thereafter, Lifesaver was comparable to the F2F group at 3 months (-3.35; $p=0.493$) and 6 months (-2.07; $p=0.809$).

The combined group outperformed Lifesaver at all time points for compression depth. Overall there was little difference between F2F only and the combined group for compression depth except for the 6-month interval for depth ($p=0.009$). Chest compression depth in F2F only and the combined group suffered from attrition at 3 months but improved at 6 months. In contrast, chest

compression depth appeared to improve over 6 months for the Lifesaver only group. Overall, mean chest compression depth was shallower than the recommended depth of 50-60mm according to European Guidelines across all time points in all groups [15].

For the primary outcome of chest compression rate, all three groups performed close to recommended rates of 100-120 compressions/minute [15]. There was no significant difference between Lifesaver only and the combined group for compression rate immediately following training however the Lifesaver only group outperformed the combined group thereafter (3 months difference +19.5 p=0.043; 6 months difference +16.23 p=0.024). The changes over time were similar across all groups, with a slight drop in rate, but this did not differ significantly between groups (F=0.927; p=0.451).

Secondary outcomes (Tables 2 and 3)

All participants managed to perform CPR with flow fraction above 60% immediately after training, with Lifesaver only highest at 80.33% compared to 73.55% in F2F only and 64.09% in the combined group. Flow fraction deteriorated during follow-up across all groups but the deterioration was slowest in the combined group (F=4.874, p=0.001).

The combined group performed the best for the CPR assessment score and also the proportion of students who were assessed to have achieved adequate CPR by the assessors. The superior assessment scores and rates of CPR achievement were seen at both skill acquisition stage and up to 6 months post training. There was a significant difference at all time points both in the CPR score and the CPR achievement in favour of the combined group when compared with F2F and Lifesaver only.

Attitudes towards resuscitation improved significantly in all three groups after training (F2F p=0.0016, Lifesaver p=0.0266, combined p<0.0001). The highest attitude score after training was in the Lifesaver group (17.04 ± 2.07).

Discussion

To date there have been no comparative studies investigating the use of immersive interactive scenario training as a standalone education tool or in combination with F2F instructor-led training. This study endeavours to fill that gap. The results from this study suggest that Lifesaver has a potential role to play in the education of school children in life support skills.

The most important metrics regarding successful CPR, and therefore our primary outcome measures, were the chest compression rate and depth. For the outcome of chest compression depth, the Lifesaver group performed the worst on initial assessment. Students exposed to F2F only training performed better than the Lifesaver only group immediately following training. There was no difference at 3 and 6-month follow up for compression depth between these two groups. Chest compression depth improved consistently in the Lifesaver group, which may reflect the opportunities to independently access the programme for refresher sessions in the interim.

None of the groups at any time point achieved compression depths compliant with international guideline recommendations (40-50mm). The ability of children to deliver guideline compliant compression depth is dependent upon their age and weight. Previous studies have documented mean compression depths for 13-year-old children ranging between 24.5mm (SD 4.5) [16] and 35mm (SD 7.8) [17]. These findings are comparable to our reported data. We feel that it is still important to train children according to guideline compliant depths as they are more likely to remember and achieve these depths as they mature.

There was no significant difference in performance between students in the Lifesaver group compared with the F2F only group in terms of compression rate.

When comparing the Lifesaver group with the face-to-face group for the secondary outcomes, the F2F group scored significantly better on the immediate CPR score and CPR achievement score. Thereafter, there was no difference between the two groups. This may once again reflect the ability for students to revisit the Lifesaver training as often as they wanted in the intervening time.

The implication therefore is that exposure to Lifesaver only may be as effective as F2F training for most aspects of CPR performance. The true benefit however for Lifesaver is in its combination

with F2F training. The combined group demonstrated superiority over F2F training alone in chest compression depth at 6 months, CPR score (at all time points), CPR achievement score (at all time points) and attitude. Not surprisingly, the combined group also demonstrated superiority compared with the Lifesaver group for many of the outcomes, although the Lifesaver group performed better regarding chest compression rate.

One of the key interactive components of Lifesaver is the direct real-time feedback given to the user if their compression rate is correct. A new virtual reality version released in 2017 has also built in feedback based upon compression depth which may further enhance performance. Lifesaver has the added advantage that it can be used for ongoing reinforcement of the principles learnt in the face-to-face teaching session. Whilst we did not specifically collate information about frequency of use during the six months, it has the potential to provide that reinforcement.

The benefit of Lifesaver is that it does not need any additional equipment (e.g. manikins). It is not reliant on pre-booked instructor time and it has the potential to reach into all elements of society, particularly those usually difficult to reach by F2F means. As opposed to fixed training sessions, Lifesaver enables the user to refresh their training at their convenience as frequently as they require. The Education section of the 2015 European Resuscitation Guidelines [25] recommended high frequency low dose updates to prevent the skills decay that normally occur within 3-12 months after BLS training. In addition to its potential use in initial training, Lifesaver is therefore an ideal vector to deliver this type of retraining.

Other studies have analysed the impact of 'serious gaming' to prepare students for CPR training. Creutzfeldt et al [18-20] utilised multiplayer virtual world technology with avatars in a full-scale CPR simulation and found improved adherence to guidelines and correct frequency of chest compressions. Semeraro et al [21-22] assessed the feedback from the use of a mini-virtual reality enhanced manikin (Mini-VREM) and found that it improved the quality of chest compression rate and depth when compared with no feedback. Semeraro et al [24] also reported the positive impact of an online game called Relive on chest compression rate, depth, and also theoretical knowledge.

There are several limitations with this study. The numbers studied were small and this means that the results are suggestive of trends rather than definitive proof. There was also a small loss to follow up. Academy schools from one only region of the country were included and the results

may not reflect performance in other parts of the UK. The study would have been strengthened if we had randomised at an individual level. The decision to analyse the three arms of the study in separate schools was made to avoid contamination of the trial intervention (e.g. friends from other classes sharing the Lifesaver product with colleagues in the F2F only group). The results cannot be generalised to other age groups. The purpose of this study was a proof of concept and it is essential that further studies now build upon this work.

Conclusions

Use of the Lifesaver programme by school children, compared to F2F training alone, can lead to comparable learning outcomes for several key elements of successful CPR. Whilst children of this age are physically unable to achieve guideline compliant compression depths, they should still be taught the correct depth as they will gain the ability to achieve this as they mature. This is a concept that may require further research.

The use of Lifesaver should therefore be considered where resources or time do not permit formal F2F training sessions. Most importantly, it helps to raise awareness of the importance of CPR and promotes a positive attitude to helping others when faced with such an emergency. From this perspective, it is potentially better than receiving no training at all. The true benefits of Lifesaver can be realised however if it is paired with F2F training.

Acknowledgements

The study was funded by a research grant from Resuscitation Council (UK). The authors would like to thank Laerdal Medical UK for the loan of study equipment. Laerdal Medical UK was not involved in the preparation of the manuscript. Additionally, the authors would like to thank Dr Jonathan Hulme, Dr Joe Aldermann, Joanne Blake (layperson PPI), the NIHR Clinical Research

Network West Midlands Young Persons' Steering Group and the medical students for their contribution to the study. JY is supported by a NIHR post-doctoral fellowship.

Trial registration: NCT03151785, registration date 29/06/2016

References

1. Perkins GD and Cooke MW. Variability in cardiac arrest survival: the NHS Ambulance Service Quality Indicators. *EMJ* 2012;29:3-5
2. Berdowski J, Berg RA, Tijssen JG et al. Global incidences of out-of-hospital cardiac arrest and survival rates: systematic review of 67 prospective studies. *Resuscitation* 2010;81(11):1479-87
3. Hawkes C, Booth S, Ji C, Brace-McDonnell SJ et al. Epidemiology and outcomes from out-of-hospital cardiac arrests in England. *Resuscitation* 2017;110:133-140
4. Seattle and King County Council Division of Emergency Medical services 2012 Annual report. 2012.
http://www.kingcounty.gov/healthservices/health/ems/~/_media/health/publichealth/documents/ems/2012AnnualReport.ashx
5. Kanstad BK, Nilsen SA, Fredriksen K et al. CPR. Knowledge and attitude to performing bystander CPR among secondary school students in Norway. *Resuscitation* 2011;82(8):1053-9
6. Malta Hansen C, Kragholm K, Pearson DA et al. Association of Bystander and First-Responder Intervention With Survival After Out-of-Hospital Cardiac Arrest in North Carolina, 2010-2013. *JAMA* 2015;314(3):255-264
7. Wissenberg M, Lippert FK, Folke F, et al. Association of national initiatives to improve cardiac arrest management with rates of bystander intervention and patient survival after out-of-hospital cardiac arrest. *JAMA* 2013;310:1377–84
8. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/217118/9387-2900853-CVD-Outcomes_web1.pdf
9. Perkins GD, Lockey AS, Belder M et al. National initiatives to improve outcomes from out-of-hospital cardiac arrest in England. *Emerg Med J* 2016; 33: 448–451
10. <https://www.england.nhs.uk/south/wp-content/uploads/sites/6/2016/12/resuscitation-to-recovery.pdf>
11. Plant N and K Taylor. How best to teach CPR to schoolchildren: A systematic review. *Resuscitation* 2013;84(4):415-421
12. Iserbyt P, Charlier N, Mols L. Comparison of instructor-led automated external defibrillation training and three alternative DVD-based training methods. *Resuscitation* 2014;85:809-13
13. Iserbyt P, Charlier N, Mols L. Learning basic life support (BLS) with tablet PCs in

- reciprocal learning at school: are videos superior to pictures? A randomized controlled trial. *Resuscitation* 2014;85:809-13
14. de Vries W, Handley AJ. A web-based micro-simulation program for self-learning BLS skills and the use of an AED. Can laypeople train themselves without a manikin? *Resuscitation* 2007;75(3):491-8
 15. Perkins GD, Handley AJ, Koster RW et al. European Resuscitation Council Guidelines for Resuscitation 2015: Section 2. Adult basic life support and automated external defibrillation. *Resuscitation* 2015;81-99
 16. Beard M, Swain A, Dunning A, Baine J, Burrowes C. How effectively can young people perform dispatcher-instructed cardiopulmonary resuscitation without training? *Resuscitation* 2015;90:138-142
 17. Jones I, Whitfield R, Colquhoun M, Chamberlain D, Vetter N, Newcombe R. At what age can schoolchildren provide effective chest compressions? An observational study from the Heartstart UK schools training programme. *BMJ* 2007;334:1201
 18. Creutzfeldt J, Hedman L, Medin C et al. Exploring virtual worlds for scenario-based repeated team training of cardiopulmonary resuscitation in medical students. *J Med Internet Res* 2010;12(3):e38
 19. Creutzfeldt J, Hedman L and Tsai L. Effects of pre-training using serious game technology on CPR performance – an exploratory quasi-experimental transfer study. *Scand J of Trauma Resuscitation and Emergency Medicine* 2012;20:79
 20. Creutzfeldt J, Hedman L, Heinrichs L et al. Cardiopulmonary resuscitation training in high school using avatars in virtual worlds: an international feasibility study. *J Med Internet Res* 2013;15(1):e9
 21. Semeraro F, Frisoli A, Bergamasco M and Cerchiari E. Virtual reality enhanced mannequin (VREM) that is well received by resuscitation experts. *Resuscitation* 2009;80(4):489-92
 22. Semeraro F, Frisoli A, Loconsole C et al. Motion detection technology as a tool for cardiopulmonary resuscitation (CPR) quality training: a randomised crossover mannequin pilot study. *Resuscitation* 2013;84(4):501-7
 23. Semeraro F, Frisoli A, Loconsole C et al. Kids (learn how to) save lives in the school with the serious game Relive. *Resuscitation* 2017;116:27-32
 24. Greif R, Lockey AS, Conaghan P et al. European Resuscitation Council Guidelines for Resuscitation 2015: Section 10. Education and implementation of resuscitation. *Resuscitation* 2015;288-301

